[REPORT OF THE SECRETARY OF THE NAVY, 1889. pp 414-425.]

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OF

THE SUPERINTENDENT

OF THE

U. S. NAVAL OBSERVATORY

FOR THE

YEAR ENDING JUNE 30, 1889.

WASHINGTON:
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U. S. NAVAL OBSERVATORY,
Washington, August 19, 1889.

SIR: I have the honor to submit, in compliance with the Bureau's order of the 6th instant (No. 1816 *b*) the report of the Naval Observatory for the fiscal year ending June 30, 1889.

The following changes in the personnel have occurred. Detachments: Commander A. D. Brown, on October 30, 1888; Lieut. William P. Elliott, March 13, 1889; Lieut. L. C. Heilner, April 18; Lieut. A. G. Winterhalter, April 29; Ensign A. N. Mayer, April 19, 1889. Assistant Astronomer William C. Winlock resigned May 14, 1889. Reported for duty: Lieut. Hiero Taylor, November 27, 1888; Lieut. W. O. Sharrer December 20, 1888, and Ensign J. A. Hoogewerff, June 1, 1889.

DIVISION OF WORK—OFFICERS IN CHARGE.

Assistant to Superintendent.—This office ceased to exist on the detachment of Commander Brown, and the duties formerly pertaining to it have, since December, been performed by Lieutenant Sharrer.
Chronometers and time service.—Lieut. Hiero Taylor.
East transit instrument.—Lieut. B. W. Hodges.
Inspection of instruments.—Ensign A. B. Clements.
Magnetic instruments.—Ensign C. C. Marsh.
Great equatorial.—Prof. Asaph Hall.
Transit circle.—Prof. J. R. Eastman.
9.6-*inch equatorial.*—Prof. Edgar Frisby.
Library.—Assistant Astronomer H. M. Paul.
Instrument-maker.—William F. Gardner.
Clerk.—Thomas Harrison.

The meteorological observations were made by the watchmen, Dennis Horigan, Nicholas Cahill, and William Henderson.

Prof. William Harkness is also attached to the Observatory for special duty as the member of the Transit of Venus Commission, having direct charge of the reductions and computations of the observations of 1874 and 1882. His report of the progress of the work is hereto appended, marked Appendix B.

THE GREAT EQUATORIAL.

(Professor Hall, in charge.)

This instrument has been employed in observing double stars and the satellites of Saturn. Attention was also given to the appearance of this planet, to the divisions of the ring, and to the shadows. As the satellite Iapetus had returned to nearly the same apparent position with respect to Saturn that it had in 1875, a new series of observations by the method of differences of right ascension and declination was made at the last opposition. These have been reduced and are nearly ready for discussion. The drawings of Saturn have been finished, and the notes on the appearance of the planet made since 1875 have been sent to the printer. These drawings and notes will appear as Appendix II to the volume for 1885.

Ensign H. S. Chase has been employed on the work of this instrument, in revising the reductions and in preparing the observations for publication.

Mr. George Anderson has had charge of the dome and the gas-engine.

The instrument is in good order.

THE TRANSIT CIRCLE.

(Professor Eastman, in charge.)

The transit circle has been employed on observations of the sun, moon, major and minor planets, and such stars as were necessary for clock and instrumental corrections. The observation of a small list of stars for the U. S. Coast and Geodetic Survey has also been undertaken.

The assistants on the work of this instrument have been Assistant Astronomer A. N. Skinner; Assistant Astronomer H. M. Paul, to November, 1888; Assistant Astronomer W. C. Winlock, to May 14, 1889; Computer William M. Brown; Computer A. S. Flint, since November 24, 1888.

From October 9, 1888, to June 30, 1889, 1,700 observations were made with the transit circle. Of this number 68 were of the sun, 50 of the moon, 93 of the major planets, 18 of the minor planets, and 5 of Comet *e* 1888. Clock signals were exchanged with Buchtel College Observatory, Akron, Ohio, on six nights in December and January to determine the longitude of that observatory.

The reduction of the observations which have been accumulated with this instrument has delayed observations on the zone of stars for the German Astronomical Society.

The transit circle work for 1885 is nearly ready to be copied for the printer, and the reductions for 1886 are now in hand.

But one of the two additional computers estimated for last year was authorized by Congress; he has not yet been appointed. The other is asked for in the estimates recently submitted. It is earnestly hoped that the services of both, so greatly needed, may be obtained.

THE 9.6-INCH EQUATORIAL.

(Professor Frisby, in charge.)

This instrument has been used for the identification of stars whenever necessary, and for the observation of small planets, comets, and occultations of stars by the moon. Three comets have been seen, and observed whenever possible; the observations have all been reduced and published in the *Astronomical Journal*. Two evenings in the week have been set apart for the accommodation of visitors. Permits for 1,665 visitors were issued.

The revision of Yarnall's Catalogue of Stars has been completed, and the work is nearly ready for distribution.

VARIABLE STARS.

For the last year and a half, Assistant Astronomer H. M. Paul has been engaged upon observations of a list of stars which have at various times been suspected of variability in brightness. One of the results of this work has been the discovery of a new variable in the constella-

tion *Antlia*, with a period of less than twelve hours, the shortest period yet known. These observations will be published as soon as they can be prepared for the printer.

CHRONOMETERS AND TIME SERVICE.

(Lieutenant Taylor, in charge.)

Lieutenant Taylor reported for duty November 27, 1888. Ensign Mayer had been in charge up to that time and continued on duty here until April 19, 1889, when he was detached.

The records show that during the year chronometers have been issued to eleven ships and one shore station. Chronometers have been received from the same number of ships and shore stations. The chronometers received from the *Nipsic* and the *Vandalia* were so damaged that they have not been sent to the makers for repairs; other chronometers received were sent to the makers for necessary repairs. Two box chronometers have been condemned for use as hack-chronometers. In October, 1888, fourteen chronometers were purchased. Fifty-six chronometers received from makers, cleaned and repaired, were placed under trial in the temperature-room December 23, 1888, and kept there until March 6, 1889. The routine observed in the temperature-room was the same as for the trial of 1887–88. The only mishap occurred two days before the end of the last term at 45°, when a leak from the ice-chamber was discovered. The chronometers were not injured, and the trial in the chronometer-room has been completed. The records of this trial are given in Appendix A. The following table shows the number and disposition of the chronometers belonging to the Government at the end of the fiscal year:

Disposition of chronometers.	Box.	Hack.	Disposition of chronometers.	Box.	Hack.
Ready for issue	21	1	Repairing	32	2
Issued	145	73	Loaned	3	3
Trial	56	.....			
For repairs	25	136	Total	282	215

In addition there are: 7 chronometric watches, 6 hack-chronometric watches, 4 comparing watches.

No changes have been made in the routine of sending out time signals. The signals are sent every day, Sundays and holidays excepted, over the wires of the Western Union Telegraph Company, and time-balls are dropped at noon, 75th meridian, at Boston, Wood's Holl, Newport, New York, Philadelphia, Baltimore, Hampton Roads, Savannah, and New Orleans. The Washington time-ball is worked by signals over a Government wire leading from the Observatory to the State-War-and-Navy building. With the single exception of Newport, the Observatory receives no reports from time-ball stations. Such reports, if it were possible to get them, would be valuable.

The signals have also been used to correct the clocks on the Observatory clock line. This service has been on the whole satisfactory. The only serious trouble occurred in September, 1888, when the line was grounded in the new Government cable. The clocks up to the ground were corrected as usual, and beyond it by the use of a battery loaned by the Western Union Telegraph Company, the signals being repeated from the company's office. The line is in good condition now, and the service is so satisfactory that there is a demand for its extension to all the Government buildings.

EAST TRANSIT INSTRUMENT.

(Lieutenant Hodges, in charge.)

Lieutenant Heilner was in charge until April 18, and was succeeded by Lieutenant Hodges.

The instrument and all its connections are in good condition. The clocks have performed well. Observations have been taken to determine the corrections of the clocks whenever the weather permitted. Owing perhaps to the excessive amount of rainy weather the standard mean time clock has acquired a steady gaining rate of from two to three tenths of a second a day, having previously had a small losing rate.

INSPECTION OF INSTRUMENTS.

(Ensign A. B. Clements, in charge.)

Class A, sextants and octants.—There were on hand at the time of the last annual report thirty-one sextants; eight have been received from Fauth & Co., having been repaired, and eight have been issued to ships in commission, leaving thirty-one now on hand. Of these, four are small hydrographic sextants, all ready for issue, and twenty-seven are of full size. Of the large sextants, twenty-two are in good condition for issue.

Class B, thermometers.—A Draper recording thermometer similar to the one examined last year was received from the agents in this city and placed under comparison. The results of this comparison only emphasized the conclusions of the previous trial. The recording apparatus works well, but the thermometer does not respond quickly to changes of temperature, and it can not be regarded as a reliable instrument for use in the service.

Class C, spy-glasses.—There have been received from various makers five spy-glasses, which were carefully examined, but they were not recommended for use in the service, and they have been returned to their owners.

Class D, station pointers.—No instruments of this class have been received for examination.

Class E, clinometers.—None received for examination.

Class F, barometers.—None received for examination.

Class G, binocular glasses.—Sixty-one binoculars have been examined. Of these twenty-seven were of the pattern referred to in the last annual report, and twenty were purchased; six were found defective and returned to makers, and one still awaits action. The remaining thirty-four, embracing many different constructions, were carefully examined, but, being found to be unsuited to the use of the service, were returned to the makers.

There are now on hand three; one the property of Levy, Dreyfus & Co., New York, one of the novel construction patented by Steinheil & Son, retained as a sample but unfit for issue, and one, a standard glass, in good condition.

RECAPITULATION.

	On hand at last report.	Received.	Issued.	Returned to maker.	On hand.
Sextants	31	8	8	.....	31
Thermometers	2	1	.....	1	2
Spy-glasses	1	5	.....	5	1
Binocular glasses	3	61	21	40	3

MAGNETIC INSTRUMENTS.

(Ensign Marsh, in charge.)

Lieut. Wm. P. Elliott was in charge until March 13, 1889, when he was succeeded by Ensign C. C. Marsh, with Ensign J. A. Hoogewerff as an assistant since June 1.

The self-recording magnetometer has been in operation continuously, with the exception of about ten days, from January 1 (when all the magnetographs were examined, cleaned, and, when necessary, readjusted), and an occasional stoppage of the clock, caused generally by the balance arrangement of the shades getting out of order. A new agate knife-edge was fitted to the vertical-force magnetograph, and has worked satisfactorily. As no change was made in the distance of the mirror of the declination magnetograph from the recording cylinder, the value of last year was retained, viz:

Declination.—One centimeter of ordinate=11′.29 of arc.

The value of 1 millimeter of ordinate of the horizontal and vertical-force magnetographs has been determined, at intervals of about one month, by the method of double deflections, the last, on June 12, giving—

Horizontal force, 1^{mm} of ordinate=.00004687 c. g. s. units.

Vertical force, 1^{mm} of ordinate=.00004302 c. g. s. units.

The temperature co-efficients of the H. F. and V. F. magnetographs have been determined by experiment once every three months, the last, June 13, giving—

Horizontal force, change of 1° C.=1.47 millimeters.

Vertical force, change of 1° C.=1.61 millimeters.

Observations of absolute declination have been taken twice a day, generally between 9 and 10 a. m. and 3 and 4 p. m., and from them the value of the photographed base-lines of the declination magnetographs is deduced. The performance of the large declination magnet and theodolite is good.

Observations have been made on Tuesday of each week for the determination of the absolute horizontal intensity, and once each month they have been made with the inertia cylinder attached to the magnet. The magnetometer and magnets are in good order.

Observations of the magnetic inclination have been made, using three needles in rotation, in the forenoon and afternoon of every Monday and Friday. The dip circle and needles are in good condition.

Drawings of the composite curves, taken from the declination magnetograms, are made for each month and negatives taken from them, so that prints can be made to send to other observatories and persons interested in terrestrial magnetism.

A full set of original photographs of the curves (of which there are now two—made by using two papers on each cylinder) is sent to Kew each month.

This division has been furnished with copies of the magnetograph curves of declination from Toronto and Los Angeles. All disturbed days are selected, and a comparison of the disturbances is made by tracings of the curves reduced to the same scale and placed over each other. These tracings are copied on blue or "nigrosine" paper, and the prints sent to observatories and persons interested.

The results of the observations, besides being recorded in figures, are, when practicable, put in the form of curves, so that all changes and variations in the terrestrial magnetism can be readily seen and compared with the occurrence of other natural phenomena.

Two seismoscopes and a seismograph have been purchased and set up within a few months, and are in good working order. They are examined from time to time, and the clocks connected with the seismoscopes are carefully rated. The seismoscopes are of the Rose-Polytechnic-Institute pattern; one is in the basement of the magnetograph building, with the seismograph, Lick-Observatory pattern, and the other is on a pier in a small building not in use at present.

THE INTERNATIONAL ASTROPHOTOGRAPHIC CONGRESS, ETC.

The preparation of the report, upon which Lieut. A. G. Winterhalter had been engaged up to the time of his detachment from the Observatory, was continued by him at the torpedo station in addition to his other duties.

The manuscript of Part I, comprising an account of the International Astrophotographic Congress, was sent to the Public Printer in September last; the remainder, containing the details of a visit to various European observatories under orders of the Department, has since been forwarded to the printer. Proof has been received and read since May last, and an early completion of the printing of the report may be expected.

THE LIBRARY.

(Assistant-Astronomer Paul, in charge.)

The library contains, according to the accession book, up to June 30, 12,226 volumes and 2,696 pamphlets. The accessions since the date of the last report have been 308 in number, 235 volumes and 73 pamphlets. Of these, 209 were received as exchanges and 99 by purchase.

The exchange list has been recently revised, and now contains 1,278 names, distributed as follows: Home institutions, 321; individuals, 244; foreign institutions, 244; individuals, 469. In the distribution of the observatory publications the general rule is to send the annual volumes to institutions and the separate reprints of the astronomical appendices to individuals.

The following publications are in the hands of the printer, and will soon be issued:

1. The annual volume for 1884.
2. 1884, Appendix I. A third edition of Yarnall's Catalogue of Stars, prepared by Professor Frisby.
3. 1885, Appendix I. International Astrophotographic Congress, by Lieut. A. G. Winterhalter.
4. 1885, Appendix II. Saturn and its Ring, by Professor Hall.

Assistant-Astronomer Paul has recently been placed in charge of the library in addition to other duties. The services of a librarian's assistant, for which estimates have been submitted, are very much needed.

Very respectfully,

R. L. PHYTHIAN,
Captain, U. S. Navy, Superintendent.

The CHIEF OF THE BUREAU OF NAVIGATION.

APPENDIX A.—*Record of trial of repaired chronometers*, 1888–'89.

[In temperature room from December 23, 1888, to March 6, 1889; after that date in chronometer room.]

Time				Dec. 23 to Dec. 30	Dec. 31 to Jan. 7	Jan. 8 to Jan. 15	Jan. 17 to Jan. 24	Jan. 25 to Feb. 1	Feb. 2 to Feb. 9	Feb. 12 to Feb. 19	Feb. 21 to Feb. 28	Mar. 1 to Mar. 6	Mar. 6 to Mar. 13	Mar. 13 to Mar. 20	Mar. 20 to Mar. 27	Mar. 27 to Apr. 3
Temperature, Fahrenheit				44°.93	55°.12	69°.91	85°.00	89°.93	84°.88	70°.11	54°.96	45°.70	57°.16	62°.16	61°.86	63°.13
Relative humidity, per cent				70.7	68.7	70.7	66.4	61.9	61.0	63.4	64.0	69.0	55.0	64.0	62.0	64.0
	Repaired by—	*No.*	*Maker.*	*s.*	*s.*	*s.*	*s.*	*s.*	*s.*	*s.*	*s.*	*s.*	*s.*	*s.*	*s.*	*s.*
1	Negus	1334	T. S. & J. D. Negus	+0.487	+1.463	+1.631	+0.647	−0.006	+0.853	+1.511	+1.121	+0.510	+1.576	+1.659	+1.740	+1.734
2	do	1655	do	−0.941	−0.394	−0.369	−0.889	−1.399	−1.111	−0.703	−0.307	−0.640	+0.004	−0.091	−0.153	−0.051
3	do	1454	do	−1.299	−0.037	+0.203	−0.781	−1.470	−0.576	+0.083	−0.271	−0.890	+0.433	+0.409	+0.633	+0.627
4	do	1444	do	−1.977	−0.287	+0.024	−0.389	−1.149	−0.290	+0.261	−0.771	−1.590	−0.174	−0.163	−0.117	−0.016
5	do	950	do	−1.191	+0.320	+0.774	+0.326	−0.399	−0.147	+0.547	−0.164	−0.640	+1.397	+1.516	+1.276	+1.663
6	Bond	199	Wm. Bond & Son	+1.201	+1.963	+1.881	+0.647	−0.399	+0.496	+1.761	+1.657	+1.260	+1.897	+2.051	+2.026	+2.091
7	do	2007	Poole	−0.941	+0.963	+2.060	+2.219	+1.994	+2.531	+2.047	+0.729	−0.540	+0.826	+1.266	+1.383	+1.770
8	do	294	Wm. Bond & Son	+4.559	+3.856	+2.274	+1.290	+0.780	+1.389	+2.476	+3.407	+4.310	+3.361	+3.159	+3.026	+2.984
9	do	446	do	−0.227	+0.892	+0.631	−0.710	−1.577	−0.647	+0.761	+0.586	+0.060	+0.504	+0.551	+0.490	+0.663
10	Negus	1293	T. S. & J. D. Negus	−1.727	−0.680	−0.797	−1.460	−2.041	−1.576	−1.239	−1.807	−2.240	−1.139	−1.020	−0.939	−0.801
11	do	1738	do	+1.201	+0.463	+0.310	+0.326	+0.066	+0.174	−0.203	−0.379	+0.060	+0.040	+0.194	+0.169	+0.199
12	do	1272	do	−2.549	−1.323	−0.761	−1.460	−2.220	−1.611	−1.024	−1.986	−2.990	−1.674	−1.234	−1.224	−1.016
13	Bliss	1081	De Silva	−0.834	+0.677	+1.310	+0.326	+0.327	+0.317	+1.119	+0.336	−0.740	+0.826	+1.087	+1.097	+1.234
14	Negus	1120	T. S. & J. D. Negus	−1.513	−0.180	+0.739	+0.540	+0.030	+0.281	+0.583	−0.593	−1.440	−0.031	+0.159	+0.204	+0.341
15	do	725	do	−0.620	+0.284	+1.167	+1.183	+0.673	+1.210	+1.297	+0.693	+0.060	+0.219	+0.444	+0.669	+0.949
16	do	1520	do	−1.536	−0.217	−0.390	−1.731	−2.704	−1.880	−0.613	−0.753	−1.144	−0.190	−0.359	−0.027	−0.161
17	do	1597	do	−1.191	−0.430	−0.476	−0.567	−0.899	−0.790	−1.024	−1.236	−1.640	−1.031	−0.984	−0.867	−0.766
18	do	1234	do	−1.906	−0.394	−0.476	−1.210	−1.970	−1.004	−0.096	−0.200	−1.490	+0.217	+0.444	+0.454	+0.699
19	do	1266	do	−1.477	−0.430	+0.453	−0.317	−1.006	−0.361	+0.333	−0.593	−1.490	−0.317	+0.194	+0.169	+0.341
20	Bliss	2149	John Bliss & Co	−1.156	+0.249	+0.560	−0.639	−1.256	−0.719	+0.261	−0.307	−0.990	+0.504	+0.944	+0.811	+1.234
21	Bond	397	Edwards & Hunter	−0.977	+0.677	+0.381	+0.200	−0.613	+0.281	+0.761	−0.236	−1.340	+0.004	+0.409	+0.490	+0.734
22	do	2507	Barraud	−1.156	+0.427	+1.096	+0.361	−0.113	+0.496	+1.119	−0.057	−0.890	+0.790	+1.123	+1.240	+1.377
23	Negus	1195	T. S. & J. D. Negus	−3.084	−1.323	−0.333	−0.603	−1.041	−0.504	+0.047	−0.950	−1.940	−0.603	+0.016	+0.097	+0.306
24	do	718	do	−1.049	+0.213	+0.131	−1.281	−2.399	−1.611	+0.083	−0.271	−0.840	+0.290	+0.480	+0.526	+0.591
25	do	190	do	−1.441	−0.180	+0.167	−0.567	−1.220	−0.469	+0.333	−0.271	−0.340	+0.897	+1.159	+1.240	+1.020
26	do	1315	do	−2.120	−0.751	−0.440	−2.103	−2.970	−2.147	−0.881	−1.307	−2.290	−0.889	−0.734	−0.903	−0.909
27	do	991	do	−2.870	−1.073	−0.261	−1.389	−2.077	−1.611	−1.024	−1.950	−3.090	−1.103	−0.699	−0.796	−0.480
28	Bond	4613	Thomas Adams	−1.334	+0.677	+0.917	+1.361	+0.280	+0.710	+1.511	+0.657	−1.090	+1.076	+1.444	+1.454	+1.520
29	do	293	Wm. Bond & Son	−0.834	−0.109	−0.047	−1.424	−2.327	−1.397	−1.489	−1.129	−1.140	−0.424	−0.091	−0.367	−0.337
30	Negus	1684	T. S. & J. D. Negus	−1.709	−0.489	−1.033	−1.590	−2.667	−2.272	−1.184	−0.896	−2.040	−1.297	−1.573	−1.813	−1.854
31	Bond	505	Wm. Bond & Son	−4.799	−3.251	−2.261	−2.174	−1.791	−2.254	−3.560	−3.593	−4.490	−2.996	−3.056	−3.189	−2.980
32	Bliss	29480	Dent	−3.299	−2.537	−1.654	−0.889	−0.077	−0.076	−1.167	−2.057	−2.340	−1.496	−1.199	−1.260	−0.766

33	Negus	1470	T. S. & J. D. Negus	−1.786	−0.703	−0.961	−1.753	−2.489	−2.023	−1.291	−0.576	−1.742	−0.011	+0.210	+0.259	+0.397
34	....do	1311	.....do	−1.049	+0.356	+0.310	−1.103	−1.899	−1.254	+0.119	−0.307	−1.090	+0.219	+0.409	+0.383	+0.484
35	....do	1519	.....do	−3.750	−2.203	−1.533	−2.946	−3.953	−3.809	−2.184	−2.540	−3.694	−2.440	−2.144	−2.206	−2.069
36	....do	1282	.....do	−0.834	+1.249	+1.917	+0.826	−1.184	+0.031	+1.869	+0.836	−0.340	+1.504	+1.801	+1.811	+1.913
37	Bliss	464	Usher & Cole	−0.513	+0.999	+1.560	+0.933	+0.066	+0.139	+0.083	−0.093	−0.790	+0.576	+1.159	+1.490	+2.056
38	Negus	1244	T. S. & J. D. Negus	−2.192	−0.680	−0.190	−1.103	−2.113	−0.754	−0.274	−2.021	−3.290	−1.067	−1.091	−1.189	−0.801
39	Bond	694	De Silva	+0.309	+0.963	+0.524	−1.389	−2.470	−1.826	−0.346	−0.414	−0.740	+0.504	+0.801	+0.740	+0.913
40	....do	3276	Charles Frodsham	−0.263	+1.070	+2.881	+1.004	+0.923	+1.460	+1.797	+1.229	−0.240	+1.540	+2.133	+2.347	+2.270
41	Negus	1750	T. S. & J. D. Negus	−1.084	+0.463	+1.417	+0.219	−0.756	−0.969	−0.596	−0.057	−1.140	+0.754	+0.980	+0.990	+1.127
42	....do	775	.....do	−1.013	+0.249	+1.846	+0.611	−0.220	+0.317	+1.154	−0.129	−0.990	+0.469	+0.873	+0.954	+1.020
43	....do	1059	.....do	−0.763	+0.891	+0.917	+0.576	−0.291	+0.781	+2.190	+2.371	+1.360	+2.611	+2.730	+3.026	+2.984
44	Bliss	2101	Crisp	−4.906	−1.394	−0.226	−1.281	−2.041	−1.540	−1.346	−2.664	−5.440	−0.389	−0.663	−0.117	+0.306
45	Negus	1267	T. S. & J. D. Negus	+2.059	+2.962	+4.096	+1.683	+0.994	+1.317	+2.297	+1.800	+1.260	+2.683	+2.766	+2.597	+2.520
46	....do	1268	.....do	−2.441	+0.106	+1.381	−0.246	−1.363	−1.361	−1.917	−0.736	−3.240	−0.889	−0.377	−0.189	−0.016
47	....do	1097	.....do	−3.763	−1.644	+0.476	−2.210	−3.541	−3.219	−2.917	−3.950	−4.790	−3.174	−2.984	−2.831	−2.837
48	....do	919	.....do	−3.334	−1.287	−0.190	−1.317	−2.684	−2.290	−2.310	−4.164	−5.990	−3.853	−3.127	−3.046	−2.730
49	....do	1226	.....do	−2.084	−1.073	−0.547	−1.067	−1.470	−0.361	+0.476	−0.914	−1.590	−0.746	−0.341	−0.367	.....

APPENDIX A.—*Record of trial of repaired chronometers*, 1888-'89—Continued.

[In temperature room from December 23, 1888, to March 6, 1889; after that date in chronometer room.]

Time			Apr. 3 to Apr.10	Apr.10 to Apr.17	Apr.17 to Apr.24	Apr.24 to May 1	May 1 to May 8	May 8 to May 15	May 15 to May 22	May 22 to May 29	Temperature of compensation.	Temperature constant.	First trial number.	Final trial number.
Temperature, Fahrenheit			61°.89	64°.72	68°.13	68°.29	66° 84	76°.83	75°.46	67°.66				
Relative humidity per cent			61.4	75.0	68.3	62.7	62.5	65.2	75.1	67.9				
	Repaired by—	*No.*	*Maker.*	*s.*	*s.*	*s.*	*s.*	*s.*	*s.*	*s.*	*s.*	°	°	*s.*	*s.*
1	Negus	1334	T. S. & J. D. Negus	+1.556	+1.744	+1.524	+1.730	+1.640	+1.366	+1.417	+1.603	66.31	−0.002440	9.1549	9.6661
2	do	1655	do	−0.266	−0.256	−0.619	−0.770	−0.881	−0.991	−1.190	−0.969	52.46	−0.000617	7.6887	9.8291
3	do	1454	do	+0.520	+0.459	+0.774	+0.909	+0.783	+0.473	+0.480	+0.496	66.49	−0.002490	9.4419	10.7369
4	do	1444	do	−0.194	+0.066	+0.096	+0.230	−0.003	+0.223	+0.631	+0.746	71.24	−0.002560	11.7376	14.0268
5	do	950	do	+1.270	+1.530	+1.524	+1.516	+1.676	+1.937	+1.489	+1.460	70.07	−0.002560	11.7381	14.1035
6	Bond	199	Wm. Bond & Son	+2.091	+2.137	+2.131	+2.159	+2.104	+1.794	+1.801	+2.103	62.63	−0.002800	14.0675	14.6188
7	do	2007	Poole	+1.484	+1.780	+1.846	+1.944	+1.890	+2.187	+2.274	+2.210	82.96	−0.001970	13.9639	15.2295
8	do	294	Wm. Bond & Son	+3.056	+3.101	+3.131	+3.337	+3.461	+2.794	+2.953	+3.603	148.14	+0.000488	12.6416	15.6000
9	do	446	do	+0.556	+0.566	+0.524	+0.587	+0.497	+0.116	+0.096	+0.353	62.02	−0.002960	15.2296	15.7552
10	Negus	1293	T. S. & J. D. Negus	−0.801	−0.684	−0.547	−0.449	−0.610	−0.563	−0.654	−0.754	67.16	−0.001610	15.2231	16.2231
11	do	1738	do	+0.127	+0.137	+0.381	+0.301	+0.283	+0.651	+0.417	+0.317	61.61	+0.000413	15.2854	16.3360
12	do	1272	do	−1.194	−0.934	−0.869	−0.699	−0.824	−0.849	−1.261	−1.040	70.64	−0.003160	16.1396	16.3535
13	Bliss	1081	De Silva	+1.091	+1.280	+1.453	+1.587	+1.426	+1.330	+1.274	+1.389	69.13	−0.003560	16.0436	16.4036
14	Negus	1120	T. S. &. J. D. Negus	+0.163	+0.351	+0.417	+0.694	+0.461	+0.687	+0.917	+1.067	74.60	−0.002870	15.2999	16.8875
15	do	725	do	+0.984	+0.887	+0.774	+1.516	+1.569	+1.473	+1.417	+1.853	76.81	−0.001730	10.2539	17.2764
16	do	1520	do	−0.190	−0.239	−0.316	−0.179	−0.239	−0.689	−0.746	−0.419	62.31	−0.002870	16.5434	17.5344
17	do	1597	do	−6.766	−0.899	+0.654	−0.663	−0.610	−0.456	−0.476	−0.576	175.68	−0.000025	17.1351	18.0140
18	do	1234	do	+0.556	+0.744	+0.703	+0.659	+0.604	+0.187	+0.131	+0.460	62.70	−0.001840	17.6416	18.6168
19	do	1266	do	+0.306	+0.351	+0.631	+0.873	+0.640	+0.687	+0.703	+0.817	70.79	−0.003640	18.1556	19.2062
20	Bliss	2149	John Bliss & Co	+0.984	+1.351	+1.131	+1.409	+1.426	+1.330	+1.417	+1.710	66.81	−0.003400	16.6013	19.3238
21	Bond	397	Edwards & Hunter	+0.699	+0.851	+0.917	+1.016	+1.069	+0.830	+0.739	+0.889	70.75	−0.001420	17.9837	19.7393
22	do	2507	Barraud	+1.377	+1.566	+1.560	+1.766	+1.640	+1.723	+1.703	+1.746	71.14	−0.003560	19.1066	19.9166
23	Negus	1195	T. S. & J. D. Negus	+0.163	+0.423	+0.596	+0.909	+0.640	+0.759	+0.631	+0.781	73.12	−0.003120	18.6264	20.5529
24	do	718	do	+0.413	+0.423	+0.274	+0.337	+0.211	−0.384	−0.726	+0.031	63.71	−0.003750	22.0655	25.0861
25	do	190	do	−0.194	+0.280	+0.631	+0.873	+0.747	+0.759	+0.596	+0.889	68.23	−0.002760	12.6471	26.9960
26	do	1315	do	−1.087	−1.149	−0.761	−0.484	−0.503	−0.813	−0.833	−0.611	65.52	−0.004080	24.3334	27.0559
27	do	991	do	−0.730	−0.470	−0.333	−0.270	−0.467	−0.384	−0.654	−0.647	70.05	−0.003840	26.0056	27.1081
28	Bond	4613	Thomas Adams	+1.270	+1.637	+1.667	+1.837	+1.533	+1.973	+1.346	+1.139	73.80	−0.001610	23.8611	28.1584
29	do	293	Wm. Bond & Son	−0.480	−0.541	−0.583	−0.341	−0.467	−0.884	−0.976	−0.469	66.03	−0.003320	27.4882	28.8924
30	Negus	1684	T. S. & J. D. Negus	−2.104	−1.989	−1.959	−1.823	−1.987	−1.976	−1.959	−1.990	47.17	−0.000904	26.4067	29.1292
31	Bond	505	Wm. Bond & Son	−2.837	−3.077	−2.797	−2.341	−2.217	−2.349	−2.404	−2.076	20.76	+0.000409	28.2593	33.1434
32	Bliss	29480	Dent	−1.051	−0.756	−0.619	−0.720	−0.574	−0.527	−0.619	−0.469	−262.01	−0.000091	31.0014	34.2414

33	Negus	1470	T. S. & J. D. Negus	+0.253	−0.631	−1.137	−0.966	−1.023	−1.083	−1.067	−0.883	35.94	−0.000611	26.5023	35.0579
34	do	1311	do	+0.377	+0.209	+0.131	+0.323	−0.039	−0.313	−0.511	−0.433	64.30	−0.003510	3 .8557	35.1257
35	do	1519	do	−2.211	−1.774	−1.851	−1.821	−1.809	−2.119	−2.053	−1.861	66.29	−0.004520	33.8179	35.3185
36	do	1282	do	+1.663	+1.816	+1.917	+1.944	+1.854	+1.630	+1.774	+1.817	48.01	−0.005140	36.3529	37.0335
37	Bliss	464	Usher & Cole	+1.663	+2.244	+2.096	+2.123	+2.390	+2.009	+1.631	+1.746	70.95	−0.001450	34.2408	40.8714
38	Negus	1244	T. S. & J. D. Negus	−0.873	−0.613	−0.547	−0.234	−0.717	−0.241	+0.203	+0.103	71.75	−0.004030	38.3269	42.5294
39	Bond	694	De Silva	+0.806	+0.923	+0.989	+0.980	+0.961	+0.544	+0.453	+0.924	60.66	−0.003360	42.0131	44.3053
40	do	3276	Charles Frodsham	+2.377	+2.530	+2.669	+2.159	+2.069	+1.973	+1.846	+1.781	70.27	−0.005130	44.1522	48.0528
41	Negus	1750	T. S. & J. D. Negus	+1.020	+1.173	+1.346	+1.144	+1.319	+1.366	+1.310	+1.246	65.63	−0.002200	51.7023	53.6288
42	do	775	do	+0.806	+1.244	+1.417	+1.480	+1.354	+0.973	+0.953	+1.317	71.22	−0.005500	53.9735	55.4135
43	do	1059	do	+2.913	+2.780	+2.917	+2.587	+2.390	+2.116	+2.274	+1.996	61.03	−0.001770	55.0079	59.2433
44	Bliss	2101	Crisp	+0.163	+0.566	+0.631	+0.730	+0.569	+0.259	+0.274	+0.496	72.49	−0.001150	58.3188	65.4744
45	Negus	1267	T. S. & J. D. Negus	+2.377	+2.459	+2.631	+2.623	+2.461	+2.759	+2.953	+3.067	67.38	−0.005570	84.5719	90.4041
46	do	1268	do	−0.301	+0.137	+0.381	+0.587	−0.354	+0.366	+0.131	+0.210	67.69	−0.003520	82.9804	92.9850
47	do	1097	do	−2.873	−2.684	−2.690	−2.091	−2.217	−2.170	−2.297	−2.290	70.29	−0.004710	115.8976	119.4621
48	do	919	do	−2.980	−2.613	−2.654	−2.949	−3.003	−2.491	−2.404	−2.576	73.41	−0.004510	141.2156	143.0058
49	do	1226	do	.....	.....	.....	.....	.....	.....	.....	.....	71.28	−0.003640	32.2036	.....

APPENDIX B.

[Report of Professor William Harkness, of the Transit of Venus Commission.]

U. S. NAVAL OBSERVATORY,
Washington, August 13, 1889.

SIR: I have the honor to submit the following report of the work done during the past year, under my supervision, for the Transit of Venus Commission:

Mr. A. S. Flint was the only assistant employed at the beginning of the year, and he left the service of the Commission on November 24, 1888, because of the exhaustion of the appropriation out of which his salary was paid. Since that date I have had no assistant.

The reduction of all the photographs taken with horizontal photoheliographs of about 40-feet focus, during the transit of Venus in December, 1882, is now complete, and if we put π for the solar parallax, and δA and δD, respectively, for the corrections to the right ascensions and declinations of Venus given by Hill's tables of that planet, it being assumed that Hansen's tables of the sun are correct, the results may be stated as follows:

From position-angles measured on 1,426 photographs:

$\pi = 8.772'' \pm 0.0496''$ $\quad \delta A = +2.724'' \pm 0.0811''$ $\quad \delta D = +1.447'' \pm 0.1343''$

From distances measured on 1,475 photographs:

$\pi = 8.847'' \pm 0.0122''$ $\quad \delta A = +2.893'' \pm 0.0430''$ $\quad \delta D = +1.246'' \pm 0.0241'$

Weighted mean from both position angles, and distances:

$\pi = 8.842'' \pm 0.0188''$ $\quad \delta A = +2.856'' \pm 0.0380''$ $\quad \delta D = +1.252'' \pm 0.0237''$

From the American Ephemeris for 1882, pp. 278 and 405, we have for the epoch 1882, December $6^d\ 5^h\ 00^m$ Greenwich mean time,

Apparent right ascension of sun,	253° 12′ 35.75″
Apparent declination of sun,	−22° 33′ 17.53″
Apparent obliquity of ecliptic,	23° 27′ 09.49″
Log. distance, sun to earth,	9.9934260
Log. distance, sun to Venus,	9.8576405
Inclination of orbit of Venus,	3° 23′ 36.32″
Constant of aberration,	20.4451″

From the photographs, the observed position of Venus for the epoch in question, is—

Apparent right ascension = 253° 12′ 35.75″ − 02′ 44.424″ + 02.856″
= 253° 09′ 54.182″ + $d\alpha\odot \pm 0.0380''$.
Apparent declination = −22° 33′ 17.53″ − 10′ 21.371″ + 01.252″
= −22° 43′ 37.649″ + $d\delta\odot \pm 0.0237''$.

And from these data we find:

Apparent geocentric longitude of sun,	254° 31′ 39.976″
Apparent geocentric latitude of sun,	− 0° 00′ 00.093″
Apparent geocentric longitude of Venus,	254° 30′ 23.235″ + $d\lambda\odot$
Apparent geocentric latitude of Venus,	− 0° 10′ 33.255″ + $d\beta\odot$
True geocentric longitude of sun,	254° 32′ 00.729″
True geocentric latitude of sun,	− 0° 00′ 00.093″
Heliocentric longitude of Venus,	74° 32′ 24.611″ + $d\lambda\odot$
Heliocentric latitude of Venus,	− 0° 03′ 51.791″ − $d\beta\odot$
Longitude of Venus in her orbit = 74° 32′ 17.74″ + $d\lambda\odot$ + 0.030 $d\beta\odot$	
Longitude, ☊ = 75° 37′ 33.91″ + $d\lambda\odot$ − 16.868 $d\beta\odot$ − 0.321 di.	

With $\pi = 8.842'' \pm 0.0118''$, and 3963.296 miles for the equatorial radius of the earth, which is General A. R. Clarke's value, the mean

distance from the earth to the sun is 92,455,000 miles, with a probable error of only 123,400 miles.

The measurements of the eighty-six photographs taken at New Haven have not yet been finally discussed, and the reduction of the photographs taken during the transit of December, 1874, has never been completed. Furthermore, the contact observations made by our own parties in 1874 and 1882, and by nearly a hundred volunteer observers in 1882, yet remain unreduced. I need the services of an assistant in order to accomplish all this work with the rapidity which is desirable.

Thus far Congress has provided only for the printing of the observations of the transit of 1874; and, as these observations are now nearly all in type, I would respectfully call attention to the urgent need of some provision for the printing of the observations made in 1882. If such provision is deferred until after the manuscript is ready for the printer, much unnecessary delay will result.

Hitherto it has been customary to endeavor to determine the solar parallax as if it were an independent constant, and the result is a mass of discordant values, all of which are more or less affected by constant errors, and none of which commands anything like universal assent. But, in truth, the solar parallax is not an independent constant. On the contrary, it is entangled with the lunar parallax, the constants of precession and nutation, the parallactic inequality of the moon, the lunar inequality of the earth, the masses of the earth and moon, the ratio of the solar and lunar tides, the constant of aberration, the velocity of light and the light equation, and, according to the most elementary mathematical principles, it should be determined simultaneously with all these quantities. No other method affords anything like so much promise of eliminating the ever-present constant errors, and for that reason I took it up last fall, intending to prosecute it as a private investigation during my leisure time. The results attained were presented to the Philosophical Society of Washington on October 13, 1888, but since then, in connection with my official work, the paper has been greatly expanded and will be ready for publication in a few days. In accordance with your wishes it is to form part of the annual volume of this Observatory.

Very respectfully,

WILLIAM HARKNESS,
Professor of Mathematics, U. S. Navy,
Of Executive Committee of Transit of Venus Commission

Capt. R. L. PHYTHIAN, U. S. Navy,
Superintendent of Naval Observatory,
President of Transit of Venus Commission.